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Role of medico-administrative database in the selection of the target population in colorectal cancer screening program

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Abstract

Background: Colorectal cancer (CRC) screening in average-risk populations requires filtering a target population based on medical information in population-based CRC screening programs (CRCSP). This study describes the level of consensus in medical exclusion practice and the role of the medico-administrative databases (MADB) in accurately targeting the eligible individuals for CRCSP screening campaigns.

Design: The descriptive study combined a cross-sectional survey and a non-systematic literature review.

Methods: A cross-sectional survey was conducted among CRCSPs worldwide. Information was collected on the use of MADB for identifying consensus-based exclusion criteria (applied by >50% of CRCSPs). When a MADB was used, the study assessed whether the definition (code lists, medical terminologies) of the exclusion criteria was available. These definitions were compared between programs to evaluate the degree of consensus.

Results: In all, 20 out of the 31 CRCSPs (Australia, England, Manitoba, Ontario, Washington State, 26 European countries) participating in the survey implemented medical exclusions. Five consensus-based exclusion criteria were identified (personal history of CRC, inflammatory bowel disease, adenoma, recent colonoscopy, genetic risk). However, these criteria were not uniformly defined in MADBs (i.e., CRC phenotype includes ICD-10 codes C18–C21 in Catalonia, while the C21 code was excluded elsewhere). Furthermore, although the MADBs exist and contain relevant information, they remain inaccessible to screening management structures in some countries (e.g., in France).

Conclusion: The number of consensus-based criteria was limited, and they were the least nuanced, likely because they are easier to collect using the current CRCSPs management resources. These consensual criteria can be queried in most MADBs. However, the use of MADBs was not standardized across programs for various reasons (absence of a database, unavailability of information in the database when it exists, inaccessibility of the database when it exists), limiting comparability between them. Standardizing the five consensus criteria across all programs would only be effective if the disparity caused by systemic failures in the organization of each program was controlled.

Keywords: colorectal cancer screening, medical exclusion, medico-administrative databases, population-based program

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Introduction

Colorectal cancer (CRC) is the third most common cancer and the second leading cause of cancer-related deaths worldwide.[1] CRC screening by looking for occult bleeding in the stool, carried out every 2 years in the average-risk population, is correlated to a reduction in CRC-related mortality. The decrease in mortality becomes significant when the proportion of people screened exceeds 50% in the target population.[2,3] The CRC screening approach common in several European countries was the population-based program (CRC screening programs, CRCSP) with the systematic invitation of a target population and follow-up of people whose primary screening test result is positive. Other countries (i.e., United States of America, USA) have developed an opportunistic approach with screening by colonoscopy or fecal test.[4]

CRCSP targets an average-risk population, defined on age criteria,[4,5] absence of personal/family risk of CRC, and absence of inflammatory bowel diseases (IBD).[6,7] People with high risk (personal/family history of colorectal adenomas, CRC, or IBD) or very high risk (familial adenomatous polyposis (FAP) and Lynch-syndrome) of getting CRC and people with severe extraintestinal pathologies or colorectal disease symptom are not eligible in most CRCSPs.[6,7] Similarly, people who have undergone a colonoscopy within 5 years or a CT-colonography within 2 years are temporarily excluded if the result of this colonoscopy/CT-colonography was normal.[6,7] It follows that CRC screening in the average-risk population requires filtering a target population based on medical information.

The exclusion criteria are clearly listed,[6–8] but the data collection protocol and the applicability of each criterion are poorly documented to date. In addition to the variable ineligibility criteria, there was a disparity (1%–15%) in the proportion of ineligible people among the people invited to CRCSPs' campaigns[7] and inaccessibility of selection data in some national programs.[8] Although these previous studies[6–8] have described some providers of medical exclusion data, the reasons for choosing a morbid situation as an exclusion criterion in one program and not in another program were not clearly explained.

The campaign invitation data can be extracted from the medico-administrative databases (MADB), especially the healthcare insurance claims databases (Claims-DB).[9,10] In France, the Claims-DB (SNDS: "Système National des Données de Santé") is currently inaccessible to CRCSP's management structures, the exclusion rate (12.9%, in 2016–2017) was largely underestimated because 20% of the target population completed a colonoscopy in the last 5 years.[11] Bulliard et al.[7] report that a participation rate estimated at 45% in a target population without medical exclusion would rise to 50% if 10% of the target population were considered ineligible. However, these recommendations focused on the definition and measurement of participation rate do not highlight the impact of the ineligibility rate on the participation rate, because they are limited only to the consideration (or not) of each exclusion criterion. However, a standardization of the collection of ineligibility criteria (in type and number) between programs would facilitate the much-coveted comparability of programs.

Knowing that these earlier studies do not clarify whether the target population was systematically filtered using medical information or whether there was a consensual definition of the morbid conditions justifying medical exclusion, it is crucial to set up clear guidelines. Developing a standardized list of exclusion criteria and a consensual definition for each morbid condition warranting exclusion should be a prerequisite for any program comparison. Similarly, ensuring a reproducible method for collecting information on these criteria is essential. The use of MADBs should be a challenge for programs.

This study aims to (1) describe the strategies used to accurately target individuals truly concerned by CRCSP campaigns and (2) assess the level of consensus in the application of medical exclusion, as well as the role of MADBs and cancer registries in these strategies, particularly regarding the existence of a filtering method applicable to these databases.

Methods

Study design

The descriptive study combined a cross-sectional survey and a non-systematic literature review. A cross-sectional survey was conducted to describe the strategies used by the CRCSP's management structures (MS-CRCSP) to consider exclusion

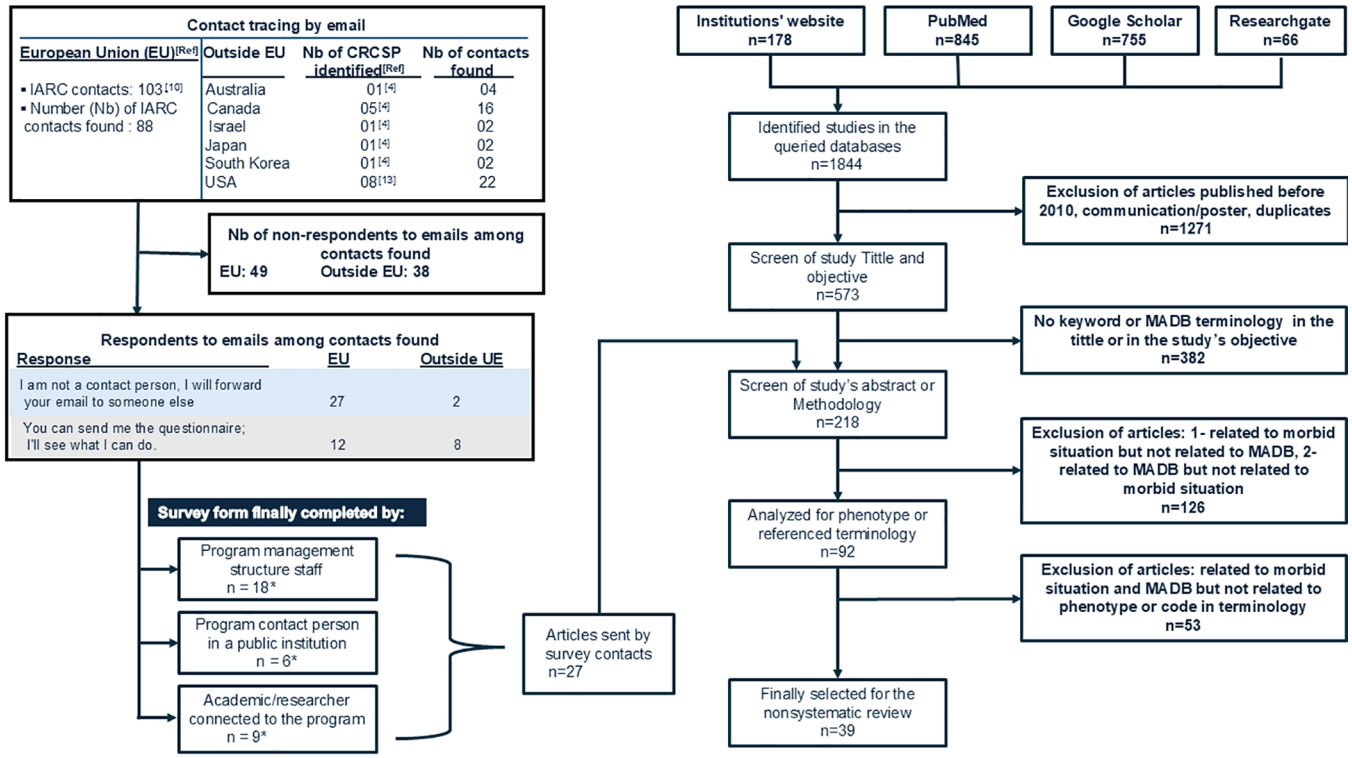


Figure 1. Survey and literature review flow charts.
*The survey form was completed by two different people for the same program.

criteria. The survey included all programs in the European Union (opportunistic or population-based, pilot, complete or incomplete rollout) that were included in previous surveys.[4,10] Fully deployed, population-based non-European-union programs were also included.[4] When a MADB was used in exclusion strategies, the study assessed whether the exclusion criteria definitions (code lists from medical terminologies) were available. A non-systematic literature review was conducted to gather these phenotypes for countries with CRCSPs practicing medical exclusion in 2021. These phenotypes were then compared across programs to evaluate the level of consensus regarding the use of MADBs and cancer registries. The study follows the Consensus-Based Checklist for Reporting of Survey Studies statement.[12]

Survey implementation

The survey was conducted between February 2022 and August 2022. The first phase focused on medical exclusion practices. The standardized form used for routine CRCSP monitoring[10] was readjusted, with the agreement of the International Agency for Research on Cancer (IARC) screening service. A list of potential participants was compiled from the IARC's database of referees who had taken part in earlier surveys.[10] To include non-European programs,[4,10] authors of recent articles (>2010) describing or evaluating CRC screening campaigns in these programs were also contacted (Figure 1).

An initial email was sent to potential study participants (i.e., 88 in the European Union), inviting them to take part. A second email, sent only to those who responded positively, included an electronic survey form (i.e., 10 of 48 potential non-EU participants received this email). Respondents to the questionnaire were listed as collaborators unless they opted out of identity disclosure.

The survey form (Supplemental Data Form 1) collected information on (i) the screening approach (opportunistic/population-based) in progress in 2021, reference to the CRCSP's definition[4]; (ii) the exclusion criteria in force in 2021: a list of 11

potential medical exclusion criteria was proposed (1: Personal history of CRC, 2: Family history of CRC, 3: Personal history of IBD, 4: Personal history of adenoma, 5: Recent colonoscopy/sigmoidoscopy/CT-colonography, 6: Patient with transient benign pathology, 7: Patient with another serious disease, 8: Patient in terminal phase of a severe disease, 9: High-risk genetic syndrome, 10: Patient with CRC' symptoms, 11: Others criteria), in accordance with the literature[6,7]; and (iii) the use of Claims-DB and cancer registries as mean. At this stage, the survey also collected data from the articles or reports sent by the contacts, and whether they responded to the survey.

In the second phase, only programs applying medical exclusions (according to the answers provided in the first phase) were surveyed to determine the availability and dissemination of exclusion data (Supplemental Data Form 2). Evaluation data from the biannual campaign (2019–2020/2020–2021) were collected.

The third phase collected information on the use of referenced databases for refining the target population (Supplemental Data Form 3). For referenced databases, whether or not they were connected to the screening database, the study collected the following: (i) the type of database: Claims-DB, Other-MADB (i.e., Hospital discharge/morbidity database), and cancer registries; (ii) the start date of data collection; (iii) the geographical area; (iv) the definition codes and terminologies of the morbid situations; (v) the availability of the data (permanent or limited retention period).

Literature review

A non-systematic literature review sought published phenotype (codes and terminology source) for each exclusion criterion applied to the database identified in the survey. Articles sent by survey respondents were reviewed first. Next, an email was sent to database managers and additional contacts found on official institutional websites.

Finally, the review was supplemented with searches on PubMed, ResearchGate, and Google Scholar (Figure 1). In the search equation using the "AND/OR" operators, the names of each listed databases were combined with each of the keywords (Colon, colorectal, Rectum, colon sigmoid, Colonoscopy, Adenoma, Polyp, Polypectomy, IBD, FAP, Hereditary Non-Polyposis CRC, Lynch Syndrome, Ulcerative Colitis, Colorectal Cancer), with publication date $\geqslant$2010.

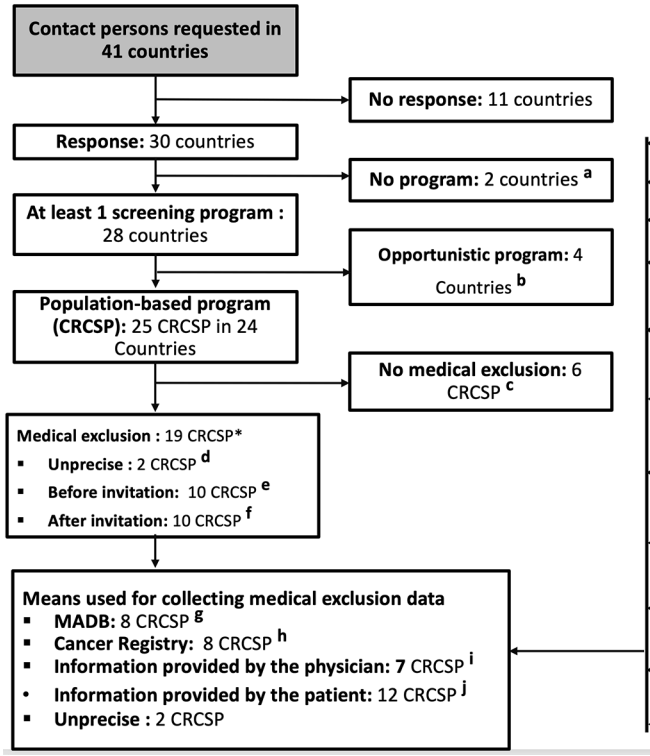
Regardless of the language of publication, articles whose title or abstract had at least one of the terminologies defining a MABD and at least one of the keywords were reviewed. The articles were reviewed by two members of the study team in France. These two experts used structured meetings or informal expert agreements to validate each process. The study was selected only if a phenotype or a list of codes in a referenced terminology (Codes of diagnostic or treatment procedure, anatomopathological or biological examination code, drug code) was available. In cases where multiple studies were collected on the same morbid situation in the same database, the most recent study was selected.

Data analysis

Medical exclusion practices. Defined as the removal of individuals with medical conditions justifying exclusion, regardless of the method used (cancer registries or other databases, data provided by patients or their attending physicians). Only quantifiable exclusions were considered about whether the strategy was the exclusion carried out before or after the campaign invitations.

Consensus-based exclusion criteria. The exclusion criterion was deemed consensual if applied by $>$50% of programs, and non-consensual if $\leqslant$50%. This threshold (50%) was a simple majority and is not based on any reference to the question. Exclusions were categorized as temporary (re-invitation possible after a waiting period) or permanent (excluded people are never re-invited).

Role of MADBs in exclusion strategies. A database was classified as national/regional if exhaustive at the national/regional level. The connection between the screening database and other databases was qualified as established if there was a systematic process for extracting or refining the target population upstream of the campaign invitations, using these connected databases. For each consensual exclusion criterion, the definition codes and terminologies, as well as the level of consensus on each definition, were described.



Medical exclusion criteria	Nb of CRCSP			
	Total /20*	Permanent exclusion	Temporary exclusion	Depending on the case
Personal history of CRC (C1)	19	13	5	1
Family history of CRC (C2)	10	5	4	1
Personal history of IBD (C3)	14	13		1
Personal history of adenoma (C4)	12	5	5	2
Recent colonoscopy/ colonography (C5)	17	1	15	1
Patient with transient benign pathology (C6)	2		1	1
Patient with another serious disease (C7)	10	6	2	2
Terminal phase of a severe disease (C8)	10	9		1
High-risk genetic syndrome (C9)	11	10		1
Patient with symptoms of CRC (C10)	9	3	4	2
Others (C11)	1			1

Figure 2. Practice of medical exclusion flow charts.
*According to the results of the survey, there was no practice of medical exclusion in Denmark. On the left, it is indicated that 19 programs practice medical exclusion. But in the sense of the study, the practice was comparable to a medical exclusion-right: 20 programs.
a: Bulgaria and Romania; b: Austria, Greece, Iceland, and Slovakia; c: Denmark, England, Germany, Lithuania, Luxembourg, and Sweden—Stockholm; d: Finland and Poland; e, g: Australia; e, g, h, i: Belgium—Flanders. e, f, g, h, and i: Canada (Ontario); e, h, i: Canada (Manitoba); f, g, i: Croatia; f, i: Czech Republic; e, f, g, h, i, j: France; e, g, h, i, j: Israel (CLALIT HMO); f, i, j: Italy (Tuscany); f, i: Malta; e, h: Norway; e, g, h: Portugal (Northern); f, g, i: Slovenia; e, f, g, h, i, j: Spain (Catalonia); f, h, i, j: Switzerland (Vaud); f, i: The Netherlands. e, i: USA (KPCHR Project).
HMO, Health Maintenance Organizations; KPCHR, Kaiser Permanente Center for Health Research.

Comparative analysis of biannual campaign data. A comparative description of these indicators was conducted according to the exclusion strategies. Indicators were described first according to the exclusion strategies if exclusion data were accessible. The target population size was the number of people in the CRC screening target age group. The number of exclusions for any reason includes medical exclusions and non-medical exclusions, such as obvious campaign refusal. The medical exclusion rate (MER) was estimated by the ratio between the number of people excluded for medical reasons and the target population size (or population invited to the campaign). The campaign participation rate (CPR) was estimated by the ratio between the number of people who had completed a primary screening test and the target population minus the total of exclusions. The coverage rate of the target population was estimated by the sum of MER + CPR. These indicators (MER, CPR, Coverage rate) were compared across programs using Pearson's Chi-square test at the 5% threshold.

Results

Practice of medical exclusion

The form was sent to 41 countries, and a response was obtained from 31 programs in 30 countries (Canada: Ontario and Manitoba). Respondents to the questionnaire included program management structure staff ($n = 18$), program contact persons in public institutions supervising the program ($n = 6$), and academics/researchers connected to the program or authors of publications on the national/regional program ($n = 9$). Among the 30 countries, 2 did not have a screening program, 4 had an opportunistic program, and 24 had a CRCSP at the regional or national level (Figure 2). In six countries, the CRCSP was either in the pilot phase (Lithuania since 2020), part

of a randomized trial project (Norway, Poland), specific to a target population based on other socio-demographic criteria (USA), or in deployment from 2022 (Finland, Germany, Norway).

In Norway, a national CRCSP program was launched in 2022, following an experiment (fecal immunochemical test every 2 years between 50 and 74 vs Flexible sigmoidoscopy once between 50 and 74) that had been ongoing since 2012.[13] In the United States, although the approach is mostly opportunistic, eight population-based programs has been identified.[14] Following the success of its demonstration program (5 pilot states: Maryland, New York, Missouri, Washington and Nebraska), the CDC has funded the implementation of additional population-based projects targeting populations covered by Federally qualified health centers (FQHCs). Other FQHCs have participated in large research projects and programs (i.e., Sea Mar Community Health Centers and the PRECISE project,[15] conducted by Kaiser Permanente Center for Health Research and funded by the National Cancer Institute; Table 1).

Of the 25 CRCSPs identified, 17 implemented medical exclusion and 2 programs (Finland, Norway) planned to introduce it in 2022 (Table 1). Six CRCSP (Denmark, England, Germany, Lithuania, Luxembourg, and Stockholm) did not refine their target populations through quantifiable exclusions. In England, the NHS Bowel Cancer Screening Program does not assume that a medical condition excludes individuals from the program, except in cases of total bowel removal. This is confirmed with a clinician to ensure that all bowel tissue has been removed, as individuals with any remaining bowel can still partake in the program. In Germany and Lithuania (pilot), CRCSP protocols implemented in 2020 did not include any exclusion. In Luxembourg, the social security center provides a target population list each month. To exclude patients with conditions potentially influencing test positivity, the patient's treating physician receives the test result 2 days before the patient, allowing the physician to explain the likely reason for a positive test and recommend a colonoscopy if necessary. In Stockholm, endoscopy units had access to the program management structure (MS-CRCSP) computer system, regularly recording cases of CRC/Polyp diagnosed in the program's age group, enabling automatic exclusion from subsequent campaigns. In Denmark, no planned exclusion was incorporated into the invitation module. However, using a unique personal identifier, the number and participation of ineligible individuals were regularly quantified in Denmark[16] (Table 1).

Medical exclusion in line with the study

Twenty programs were qualified as practicing (or potentially practicing) medical exclusion. This includes the 17 programs with established medical exclusion practices, the 2 planning to introduce medical exclusion (Finland, Norway), and Denmark, whose practice resembled medical exclusion in the context of this study. Stockholm was not added because no confirmation on the quantification of medical exclusion criteria was provided. Only five exclusion criteria (personal history of CRC, IBD, adenoma, recent colonoscopy/CT-colonography, genetic risk) were consensual across the 20 programs (Table 2).

In Flanders, individuals diagnosed with CRC in the past 10 years, those who had undergone opportunistic screening or a recent complete colonoscopy (<10 years)/CT-colonography (<4 years), and those with total colectomy were excluded from invitations using MADBs. Criteria for average-risk individuals were applied only if proof of follow-up colonoscopy was available (e.g., Italy) or if the information was present in main data sources (e.g., Ontario). Regardless of the program, individuals receiving an invitation could request exclusion for any reason, either personally or through their attending physician. In addition, invitation letters included flyers advising against screening tests for those already in personalized follow-up programs (e.g., Denmark, Flanders, Ontario).

Use of MADBs and cancer registries

The survey reveals that there was at least one MADB or cancer registry,[16–54] fully or partially covering each of the 17 states/countries/regions having a complete deployment of the CRCSP and practicing a medical exclusion. The regular connection between the Claims-DB and the CRCSP database was revealed in seven programs (Table 3). In two countries (Israel, Switzerland), the MADBs were those of insurance companies (i.e., CLALIT Database; Supplemental Data Table_Supp-1). In 2014, Washington State set up a

Table 1. Type of program by country (situation in 2021 revealed in 2022)..

Country (region or district)	Program type at launch (program launch year)	Year of implementation of the most recent screening protocol (program type in this protocol)	Screening test type (target age); time (in months) between two screening tests	Source of the target population (in pop-based program)	Practice (Yes/No) of the medical exclusion in pop-based program (means used if Yes)	Medical exclusion Timeline (in pop-based program)
Australia	Pop-based (2006)	2017 (Pop-based)	FIT (50–74); 24	B	Yes (M1)	T1
Austria	Opportunistic (1980)	2005 (Opportunistic)	gFOBT/FIT (⩾50); 12 Colo (⩾50); 120	–	–	–
Belgium (Flanders)	Pop-based (2013)	2021 (Pop-based)	FIT (50–74); 24	A	Yes (M1, M2, M4)	T1
Bulgaria	No program	No program	–	–	–	–
Canada (Ontario)	Pop-based (2008)	2015 (Pop-based)	FIT (50–74); 24	A	Yes (M1, M2, M4)	T1, T2
Canada (Manitoba)	Pop-based (2008)	2015 (Pop-based)	FIT (50–74); 24	A	Yes (M2, M4)	T1
Croatia	Pop-based (2008)	2013 (Pop-based)	FIT (50–74); 24	A, B	Yes (M1, M4)	T2
Czech Republic	Pop-based (2000)	2020 (Pop-based)	FIT (50–54); 12 FIT (>54); 24 Colo (>54); 120	B	Yes (M3)	T2
Denmark	Pop-based (2014)	2018 (Pop-based)	FIT (50–74); 24	A	No	–
England	Pop-based (2006)	2021 (Pop-based)	FIT (56–74); 24	A, D	No	–
Finland	Pop-based (2004)[a]	2022 (Pop-based)[a]	FIT (50–74); 24	D	Yes (?)	?
France	Pop-based (2009)	2018 (Pop-based)	FIT (50–74); 24	B	Yes (M1, M2, M3, M4)[b]	T1,[b] T2
Germany	Opportunistic (1974)	2020 (Pop-based)[a]	FIT (50–54); 12 FIT (>54); 24 Colo (Men 50–74); 120 Colo (Women 55–74); 120	B	No	–
Greece	Opportunistic (?)	? (Opportunistic)	–	–	–	–
Iceland	Opportunistic (?)	? (Opportunistic)	Colo (>50);	–	–	–
Israel (CLALIT HMO)[c]	Pop-based (1995)	2005 (Pop-based)	FIT (50–74); 12	B	Yes (M1, M2, M3, M4)	T1
Italy (Tuscany)[d]	Pop-based (2005)	2015 (Pop-based)	FIT (50–70); 24	A	Yes (M3, M4)	T2
Lithuania	Pop-based (2009)[a]	2020 (Pop-based)[a]	FIT (50–74); 24	A	No	–

(Continued)

Table 1. (Continued)

Country (region or district)	Program type at launch (program launch year)	Year of implementation of the most recent screening protocol (program type in this protocol)	Screening test type (target age); time (in months) between two screening tests	Source of the target population (in pop-based program)	Practice (Yes/No) of the medical exclusion in pop-based program (means used if Yes)	Medical exclusion Timeline (in pop-based program)
Luxembourg	Pop-based (2016)	2021 (Pop-based)	FIT (50–74); 24	A, B	No	–
Malta	Pop-based (2013)	2011 (Pop-based)	FIT (55–72); 24	A, C	Yes (M4)	T2
Norway	Pop-based (2012)[a]	2022 (Pop-based)[a]	FIT (55–65); 24	A	Yes (M2)	T1
Poland	Opportunistic (2000)	2012 (Pop-based)[a]	Colo (55–64); once in the lifetime	A	Yes (?)	?
Portugal (Northern)[d]	Pop-based (2008)	2018 (Pop-based)	FIT (50–74); 24	B	Yes (M1, M2)	T1
Romania	No program	No program	–	–	–	–
Slovakia	Opportunistic	Opportunistic	–	–	–	–
Slovenia	Pop-based (2009)	2015 (Pop-based)	FIT (50–74); 24	A, B	Yes (M1, M4)	T2
Spain (Catalonia)	Pop-based (2000)	2021 (Pop-based)	FIT (50–69); 24	A	Yes (M1, M2, M3, M4)	T1, T2
Sweden (Stockholm)	Pop-based (2008)	2014 (Pop-based)	FIT (60–70); 24	A	No	–
Switzerland (Vaud)[d]	Pop-based (2015)	2015 (Pop-based)	FIT (50–69); 24 Colo (50–69); 120	A	Yes (M2, M3, M4)	T2
The Netherlands	Pop-based (2014)	2021 (Pop-based)	FIT (55–75); 48	A	Yes (M4)	T2
USA (KPCHR Project)[e]	Pop-based (2014)	2018 (Pop-based)	FIT (50–75); 12 Colo (50–75); 120	A	Yes (M3)	T1[f]
No response	Cyprus, Estonia, Hungary, Ireland, Japan, Latvia, North Ireland, Scotland, Singapore, South Korea, Wales					

Source of the screening target population: (A) Population register, (B) Health insurance companies' files, (C) Electoral lists, (D) Patient lists of general practitioners or primary health care centers. Means used for medical exclusion: M1: Data from MADB; M2: Data from Cancer Registry; M3: Information provided by the attending physician or primary healthcare facility; M4: Information provided by the patient. Timeline (chronology) of medical exclusions : T1: Before the campaign invitation using data from a Cancer Registry or MADB; T2: After the campaign invitation using information provided by the patient or by their treating physician, or by a primary healthcare structure.

[a]Pilot program, a randomized trial, or a recent program in the reorganization.

[b]No structural framework, but there are partnerships in some departments between the screening structure and the cancer registries or with the primary health insurance agency.

[c]Four official not-for-profit HMOs provide CRC screening in Israel, and CHS is the largest HMO that insures about 50% of the population.

[d]In the country, none or other program than the one involved in this survey had been targeted by previous surveys.

[e]KPCHR manages the PRECISE research project funded by the National Cancer Institute (2019–2023), which is taking place in a community health network in Washington of 30 clinics (Sea Mar Community Health Centers). All community clinics have an EHR, which is their medical record system, and which is used to identify patients due for screening or follow-up.

[f]All community clinics have an electronic medical record system, which is used in the PRECISE project.

CHS, Clalit Health Services; Colo, colonoscopy; EHR, electronic health record; FIT, fecal immunochemical test; FS, flexible sigmoidoscopy; gFOBT, Guaiac fecal occult blood test; HMO, Health Maintenance Organizations; KPCHR, Kaiser Permanente Center for Health Research; MADB, medical administrative database; Pop-based, population-based.

Table 2. Duration (in years) of the exclusion according to the exclusion criteria in force in the organized programs.

Country (region or program)	Number of medical exclusion criteria in the program	Duration (in years or P, T) of the exclusion by medical exclusion criteria										
		Personal history of CRC (C1)	Family history of CRC (C2)	Personal history of IBD (C3)	Personal history of adenoma (C4)	Recent colonoscopy/ sigmoidoscopy/ CT colonography (C5)	Patient with transient benign pathology (C6)	Patient with another serious disease (C7)	Terminal phase of a severe disease (C8)	High-risk genetic syndrome (C9)	Patient with symptoms of CRC (C10)	Others (C11)
Australia	1					2						
Belgium (Flanders)	6	10	P[a]			4				P[a]	P[a]	P/T[b]
Canada (Ontario)	9	P	P[c]	P[c]	P[c]	10			P[c]	P[c]	P[c]	
Canada (Manitoba)	8	P	P	P	P	5				P	T	
Croatia	4	P			5	5		P[d]				
Czech Republic[e]	10	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	T/P	
Denmark	6	P	P	P	T	5				P		
Finland	2	10		P								
France	7	P	P	P	P	5/2[f]				P	T	
Israel (CLALIT HMO)	3	P	P			T				P		
Italy (Tuscany)[g]	6	T		P	T	T			P	P		
Malta	6	5		P	2	2		T[h]	P			
Norway (Southeast)	1	P										
Poland	4	P						P	P		P	
Portugal (Northern)	10	P	P	P	P	10/5[i]	T	P	P	P	T/P	
Slovenia	4	P		P	P	3		T/P				

(Continued)

Table 2. (Continued)

Country (region or program)	Number of medical exclusion criteria in the program	Duration (in years or P, T) of the exclusion by medical exclusion criteria										
		Personal history of CRC (C1)	Family history of CRC (C2)	Personal history of IBD (C3)	Personal history of adenoma (C4)	Recent colonoscopy/ sigmoidoscopy/ CT colonography (C5)	Patient with transient benign pathology (C6)	Patient with another serious disease (C7)	Terminal phase of a severe disease (C8)	High-risk genetic syndrome (C9)	Patient with symptoms of CRC (C10)	Others (C11)
Spain (Catalonia)	9	P	P	P	T/P[j]	T		P	P	P	T	
Switzerland (Vaud)	7	P	P	P		9.5		P	P	P		
The Netherlands	7	T		P	T	T		T	P		T	
USA (KPCHR Project)	5	P		P		P		P	P			
Number of programs using the criterion/ total		19/20	10/20	14/20	12/20	17/20	1/20	10/20	10/20	11 /20	9/20	1/20

[a]The information was given at the time of the invitation that any person concerned by the morbid situation was not concerned by the screening; they were free to participate or not.
[b]Opportunistic screening or full colectomy.
[c]These populations were not eligible for CRC screening according to program recommendations; however, this information was not accessible via the administrative databases; therefore, the program does not exclude/alter the correspondence campaign for these populations.
[d]Exclusion if data are available.
[e]Responsible for the evaluation (permanent, temporary, duration) of the criteria was the GP (alternatively, primary care gynecologist) who evaluates the criteria during periodic check-up.
[f]5 years if colonoscopy and 2 years if CT colonography.
[g]Personal history of CRC: Permanent exclusion if proof of specific endoscopic or oncological follow-up, temporary exclusion (5 years) if no proof. Personal history of IBD, Lynch disease, and PAF: Permanent exclusion if proof of endoscopic follow-up or medical follow-up, re-enter screening program if no proof of follow-up. Complete colonoscopy performed spontaneously outside the screening program: 10 years in low-risk patients if negative examination or 1–2 tubular adenomas <10 mm with low-grade dysplasia, 5 years if no information on the risk of the patient. Virtual colonoscopy performed spontaneously outside the screening program: 10 years if negative, 2 years if detection of polyps <6 mm, without immediate colonoscopy.
[h]Patients undergoing chemotherapy or radiotherapy for other cancers were excluded for about 6 months after finishing their treatments.
[i]10 years if colonoscopy and 5 years if sigmoidoscopy.
[j]The duration of the temporary exclusion depends on the type, number, and size of the adenomas.
CRC, colorectal cancer; HMO, Health Maintenance Organizations; IBD, inflammatory bowel disease; In C5, any unique value corresponds to the duration (in years) of temporary exclusion after a colonoscopy; P, permanent exclusion; T, temporary exclusion with duration in years not communicated.

Table 3. Phenotypes and algorithms defining the morbid situations which define the consensual criteria in referenced databases, the connection between the screening database and these databases (Pilot programs (Poland) and those with only a plan to achieve medical exclusion (Finland, Norway) were not included in the analysis of database use).

Country (region or program)	Claims-DB (A), Other-MADB (B), and cancer registries (C) referenced and consensual medical exclusion criteria			
	(Database type): Database name (acronym)	Link between the screening database and other databases	Terminologies of interest currently used in the database	Consensual medical exclusion criteria found (phenotype examples)[Reference studies]
Australia	(A): MBS	Linked	MBS item codes	Colo (D_1)[16,17]
	(B): NHMD	Not linked	ACHI, ARP-DRG, ICD-0-3, ICD-10, ICD-10-AM, SNOMED CT	CRC (A_2 or A_8 or A_9 or A_{10})[16,18]; IBD (B_1 or B_3 or B_4)[18]; Colo (D_2 or D_3 or D_4)[18]; Adenoma (C_4 or C_5 or C_6)[18]
	(C): ACD	Not linked	ICD-10-AM	CCR (A_1)[16,19]
Belgium (Flanders)	(A): IMA	Linked[a]	Nomenclature IMA	Colo (D_5)[20]
	(B): Minimum hospital data set (MHD-MZG-RHM)	Not Linked[b]	3BT, APR-DRG, LOINC, ICD-10-CM, ICD-10-PCS, SNOMED CT	?
	(C): Belgian Cancer Registry	Linked	ICD-10-CM	CCR (A_1)[20]
Canada (Manitoba[c] and Ontario)	(A): OHIP claims database	Linked	OHIP codes (billing and diagnostic),	Colo (D_6 or D_7)[21,22]
	(B): HMDB	Not Linked	CCI, ICD-10-CA,	CRC (A_2 or A_8)[21,23]; IBD (B_1 or B_3)[23,24]; Colo (D_8)[21]; Adenoma (C_2)[25]
	(C): Manitoba Cancer Registry and treatment	Linked	ICD-O-3	CRC (A_2)[26]
	(C): Ontario Cancer Registry	Linked	ICD-9, ICD-10-CM	CRC (A_2)[23]; CRC (A_8)[21]
Croatia	(A): Croatian primary health care database	Not Linked[b]	?	?
	(B): Croatian Hospital Discharge Database	Not Linked[b]	APR-DRG,	?
	(C): Croatian National Cancer Registry	Not linked[b]	ICD-9, ICD-10-CM	CCR (A_{16}) OR (A_{17})[27]
Czech Republic	(A): Health Insurance Database	Linked	?	?
	(B): NRHOSP	Linked	ICD-10	CRC (A_1) [31]; IBD (B_1)[28]
	(C): Czech National Cancer Registry	Linked	ICD-10	CCR (A_1)[29]
Denmark[c]	(B): DNPR	Linked	ICD-10, NOMESCO, SKS, SNOMED CT	CRC (A_1 or A_5 or A_{13})[15,30]; IBD (B_1 or B_5)[15,30,31]; Adenoma (C_7)[15]; Colo (D_{12} or D_{13})[32]; High-risk (E_1)[15]
	(C): The Danish Cancer Registry	Linked	ICD-10	CCR (A_1)[33]
France	(A)/(B): SNDS	Not linked[d]	ICD-10; CCAM	CCR (A_1)[34,35]; IBD (B_1 or B_2)[35]; Adenoma (C_1)[34]; Colo (D_9)[36]
	Isere Cancer Registry	Not linked[d]	ICD-10	CCR (A_1)[37]
Israel[c]	(B): CHS database	Linked	ICD-9	IBD (B_3)[38]

(Continued)

Table 3. (Continued)

Country (region or program)	Claims-DB (A), Other-MADB (B), and cancer registries (C) referenced and consensual medical exclusion criteria			
	(Database type): Database name (acronym)	**Link between the screening database and other databases**	**Terminologies of interest currently used in the database**	**Consensual medical exclusion criteria found (phenotype examples)[Reference studies]**
	(C): INCR	Linked	ICD-10	CRC ($A_1 + A_{11}$)[39]
Italy[c]	(B): National Hospital Discharge Database	Not linked	ICD-9	CCR (A_{14})[40]; IBD (B_3)[41]
	(C): Tuscany Region Tumor Registry	Not linked[b]	ICD-10	CCR (A_1)[42]
Malta[c]	(B): NHIS	Not linked	ICD-10; ICD-9 CM (procedures);	?
	(C): Malta National Cancer Registry	Not linked	ICD-O-2	CCR (A_1)[43]
Portugal (Northern)	(A): National Patient Database	Linked	?	?
	(B): National Hospital Morbidity Database	Not Linked	APR-DRG, ICD-9-CM, ICD-10-CM, ICD-10-PCS	IBD (B_3)[44]
	(C): RON[e]	Linked	ICD-10	CCR (A_1)[45]
Slovenia	(A): Health Insurance Institute Data (ZZZS)	Linked	ICD-10-AM	
	(B): Hospital Discharge Database	Not Linked	?	
	(C): Cancer Registry of Republic of Slovenia	Linked	ICD-10	CCR (A_1)[46]
Spain (Catalonia)[f]	(A): Primary Health Care System Registry (SIDIAP)	Linked	ICD-10	CRC ($A_1 + A_4$)[47]
	(B): Spanish National Hospital Discharge Database (RAE-CMBD)	Not Linked[b]	ICD-9-CM, ICD-10-PCS	IBD (B_1 or B_3)[48]; Colo (D_{10} or D_{11})[48]
	(C): Girona Cancer Registry	Not linked[b]	ICD10	CCR (A_{16})[47]
Switzerland (Vaud)[g]	(B): Swiss Federal Statistical Office's Database	Not linked	CHOP, ICD-10-GM	?
	(C): Vaud Cancer Registry	Not linked[b]	ICD10	CCR (A_1)[49]
The Netherlands	(A): All-payer Claims Database (Vektis)	Not Linked[b]	?	?
	(B): Dutch Hospital Discharge Data	Not Linked	?	?
	Dutch Cancer Registry	Not linked[b]	ICD10	CCR (A_1)[50]
USA (Washington)[h]	(A): All-payer Claims Database (WA-APCD)	Not Linked	CPT, HCPCS, ICD-9-CM, ICD-9-P	CCR (A_{15})[51]; IBD (B_3)[51]; Adenoma (C_5)[51]; Colo (D_{14}, D_{15}, D_{16})[51]
	(C): WSCR	Not linked	ICD10	CCR (A_2)[52]

(Continued)

Table 3. (Continued)

Country (region or program)	Claims-DB (A), Other-MADB (B), and cancer registries (C) referenced and consensual medical exclusion criteria			
	(Database type): Database name (acronym)	Link between the screening database and other databases	Terminologies of interest currently used in the database	Consensual medical exclusion criteria found (phenotype examples)[Reference studies]
Phenotypes				
Phenotypes of CRC A_1: (ICD-10: C18–C20); A_2: (ICD-10: C18.0, C18.2–C18.9, C19, C20); A_3: (ICD-10: D01.0, D01.1, D01.2); A_4: (ICD-10: C21, D01.3); A_5: (SNOMED CT: T6491, T65900, T65901, T65925, T65926, T660, T67, or T68 with morphology codes M8 or M9 with ⩾3 in the fifth position (e.g., M8XXX3)); A_6: (ICD-9: 153, 154.0, 154.1); A_7: (ICD-9: 153.0–153.4, 153.6–153.9, 154.0, 154.1, 154.8); A_8: (ICD-9: 153.0–153.4, 153.6–153.9, 154.0, 154.1); A9: (ICD-8: 153, 154.0, 154.1); A_{10}: (SNOMED CT: 126838000, 126845000); A_{11}: (ICD-10: C26.0); A_{12}: (ICD-9: 159.0); A_{12}: (OHIP diagnostic: 153, 154); A_{13}: (ICD-7: 153, 153.0, 153.4, 153.5, 154.9, 253.0, 253.1, 253.2, 253.3, 253.4, 453.0, 453.1, 453.2, 453.3, 453.4, 453.5, 453.8, 454.9, 853.0, 853.1, 853.2, 853.3, 853.4, 853.5, 854.9, 154, 154.0, 454.0, 854.0); A_{14}: (ICD-9: 153–154, 230.3, 230.4); A_{15}: (ICD-9-CM: V10.05, V10.06); A_{16} (ICD-10: C18–C21); A17: (ICD-9: 153.x, 154.0, 154.1). *Phenotypes of IBD* B_1: (ICD-10: K50.x, K51.x); B_2: (ICD-10: M07.4, M07.5); B_3: (ICD-9: 555.x, 556.x); B_4: (ICD-8: 563.0, 563.1); B_5: (ICD-8: 563.00–563.02, 563.08, 563.09, 563.19, 569.04). *Phenotypes of adenoma* C_1: (ICD-10: D12.0–D12.8); C_2: (ICD-10: D12.0, D12.2–D12.8); C_3: (ICD-10: D12.9); C_4: (ICD-10: D12.0–D12.8, K62.1, K63.5); C_5: (ICD-9: 211.3, 211.4, 569.0); C_6: (ICD-8: 211.3, 211.4); C_7: (ICD-10: D12.0–D12.6, D12.8, D12.9). *Phenotypes of colonoscopy/CT colonography/flexible sigmoidoscopy* D_1: (MBS item codes: 32084, 32087, 32222–32229); D_2: (ACHI: 32090-00, 32090-01, 32090-02, 32093-00); D_3: (ICD-9-CM: 45.23); D_4: (ICPM: 1–641); D_5: (Nomenclature code as per IMA: 72452–472463, 473174–473185, 73955–473966, 473211–473222, FULL COLONOSCOPY, POLYPECTOMY); D_6: (OHIP code: (Z555A + E740A + E741A + E747A + E705A) OR (Z49XA + E740A + E741A + E747A + E705A)); D_7: (OHIP diagnostic: 545–548); D_8: (CCI: 2NM70BABJ, 2NM70BNBJ); D_9: (CCAM: HHFC001, HHFE001, HHFE002, HHFE004, HHFE005, HHNE001, HHNE002, HHQE002, HHQE004, HHQE005); D_{10}: (ICD-9-CM: 5.23, 45.24, 45.25, 48.23, 48.24, 48.36); D_{11}: (ICD-10-PCS: 0DJD8ZZ, 0DJD8ZZ, 0DBE8ZX, 0DBH8ZX, 0DBN8ZX, 0DDE8ZX, 0DDH8ZX, 0DDN8ZX, 0D9E8ZX, 0D9H8ZX, 0D9N8ZX, 0DBP8ZX, 0D9P8ZX, 0DBP8ZZ); D_{12}: (NOMESCO: KUJF3, KUJF4, KUJG); D_{13}: (SKS procedure code: 91070, 91071, 91075, 91080, 91081, 91085, 91090, 91091, 91095, 93200, 93210); D_{14}: (CPT: 45330, 45331, 45333, 45334, 45335, 45338, 45339, 45378, 45380, 45381, 45382, 45383, 45384, 45485); D_{15}: (HCPCS: G0104, G0105, G0121); D_{16}: (ICD-9-P: 45.23, 45.24, 45.25, 45.27, 45.41, 45.42, 45.43, 48.24, 48.36). *Phenotypes of high-risk genetic syndrome* E_1: (ICD-10-DV: DD126A, DD126B, DD126C, DD126F).			

[a]The link is established through the Belgian Cancer Registry.
[b]No automated connection was established, but it was possible to do so if necessary.
[c]No Claims-DB in the country (survey result).
[d]No structural framework but there are partnerships in some departments between the screening structure and the cancer registries or with the primary health insurance funds.
[e]On January 2018, by law, a new stage for epidemiology and cancer registration began in Portugal, the four regional cancer registries (RORENO, RORCentro and ROR-Sul) became only one, national and global – RON.
[f]No Claims-DB in Catalonia, to obtain the screening target population, the most comprehensive population register of the Catalan Health Service (Central register of insured persons: Primary Health Care System Registry) was used.
[g]In Switzerland, each insurance company has its claims-DB.
[h]WA-APCD database was supplied by several other Claims-DB, such as the Centers for Medicare & Medicaid service databases.
3BT, Thesaurus Bilingal biclassified Belgian; ACD, Australian cancer database; ACHI, Australian Classification of Health Interventions; APR-DRG-X, all patient refined diagnosis related group version Xth; CCAM, Classification Commune des actes Médicaux; CCI, Canadian classification of interventions; CHS, CLALIT Health Services; Claims-DB, Regional or National Health Insurance Database; Colo, Colonoscopy/sigmoidoscopy/CT colonography; CPT, current procedural terminology; CRC, colorectal cancer; DNPR, Danish National Patient Registry; HCPCS, Healthcare Common Procedure Coding System; HMDB, Hospital Morbidity Database; IBD, inflammatory bowel disease; ICD-0-X, International Classification of Diseases for Oncology Xth edition; ICD-X, International Classification of Diseases, Xth Revision; ICD-X-AM, ICD, Xth Revision, Australian Modification; ICD-X-CA, ICD Xth Revision, Canadian adaptation; ICD-X-CM, ICD, Xth Revision, Clinical Modification; ICD-X-DV, ICD, Xth Revision, Danish version; ICD-X-GM, ICD, Xth Revision, German modification; ICD-X-PCS, ICD Xth Revision, Procedure Coding System; ICPM, International Classification of Procedures in Medicine; IMA, the intermutualistic agency; INCR, The Israel National Cancer Registry; LOINC, logical observation identifiers names and code; MADB, other medical administrative database; MBS, medical benefits schedule; NHIS, National Hospitals Information System; NHMD, National Hospital Morbidity Database; NOMESCO, Nordic Medico-Statistical Committee; NRHOSP, National Register of Hospitalized Patients; OHIP, Ontario Health Insurance Plan; RON, Registo Oncológico Nacional; SKS, Sundheds-vaesenets klassifikations system (Danish health care classification system); SNDS, Système National des Données de Santé; SNOMED CT, systematized nomenclature of medicine clinical terms; WSCR, Washington State Cancer Registry.

Claims-DB (All-Payer Claims Database, WA-APCD), which was supplied by several other Claims-DB, such as the basis of the Centers for Medicare & Medicaid service. Similarly, there was at least one cancer registry in all the countries, but it was regularly connected with the CRCSP database only in eight provinces/regions/countries (Table 3).

In three countries (Italy, Denmark, and Canada), the interconnection between screening databases and other databases was eased by the permanent personal health identification number. In Croatia, the cancer screening register was regularly updated from taxpayer databases, with the name of the general practitioner and the health insurance number provided by the Croatian Health Insurance Institute. No direct connection between the screening database and the Claims-DB existed in Croatia, but a daily transmission of exclusion cases was made by the health insurance institute. In France, no connection existed between the SNDS and the CRC screening databases, despite the SNDS contains relevant information. Each health insurance scheme (>10 in France) makes a target population list available to each regional MS-CRCSP, each quarter, without any guarantee that an exclusion had been made upstream. Exclusions were made either after returning invitation letters by post or using cancer registries, which only covered a few departments, or as part of a partnership between certain MS-CRCSPs and the primary health insurance agency.

Most of the terminologies were MADB specific, except for 3 that were used by ⩾2 MADB: (1) The All-patient refined diagnosis-related group; (2) the WHO ICD in its various versions/modifications (i.e., all cancer registries); and (3) the Systematized Nomenclature of Medicine Clinical Terms. The five consensual exclusion criteria did not have the same definition in the extracted phenotypes. In Catalonia, the CCR phenotype includes the ICD-10 codes C18–C21, while the C21 code was excluded elsewhere. In France, the IBD phenotypes include the codes M07.4 and M07.5, which were not the case in Denmark, where these phenotypes only include the ICD-10 codes K50 and K51 (Table 3).

The survey reveals the existence of two types of strategies for selecting the eligible population in the 17 CRCSPs completely implemented and performing exclusion. In Type-A, as summarized in a Portuguese study,[55] the target population was either directly extracted from MADBs or electronic health records (i.e., Washington) or linked with the MADB to extract all the medico-clinical characteristics allowing to qualify eligibility and quantify upstream the invitations, the number of people to be excluded, and the duration (permanent/temporary) of the exclusion from the program. In Type-B, a list of the target population was extracted from a source (MADB/others) and made available to the MS-CRCSP, which should go through several means to qualify eligibility and quantify the number of people to be excluded, the duration of the exclusion, usually after invitations (Figure 3).

In the programs refining target population upstream of invitations using Claims-DB, in addition to the high exclusion rate, the target population coverage rate was estimated with precision. As summarized in the Flanders report (2019–2020), the target population was 2,006,959 in 2019, and the exclusion rate (any cause) was 57.9% (Table 4). This Flanders exclusion rate was significantly ($p < 0.05$) higher than those obtained in the cohorts of people invited to the 2019–2020 campaign, in Slovenia (4.4%) and in Catalonia (4.8%). In France, where the CRCSPs are officially evaluated at a national level, the exclusion data are unavailable because the public agency in charge of the CRCSP's evaluation only publishes a global number of exclusions (medical/non-medical). To date, to have an exclusion count by criteria in France, as reported in Slovenia and Catalonia, an extraction must be requested in the databases of the 99 departments subject to regular evaluations. As an illustration, in the department of Isère, 344,973 people were invited (2019–2020 campaign). Among them, 23,241 (6.3%) were excluded for medical reasons, while this MER was only 2.0% in Haute-Savoie ($p < 0.05$). These French departments did not have the same means to refine their target populations (i.e., existence of a cancer registry in Isère), hence the significant difference in proportions.

Discussion

This study highlights the variability in exclusion strategies across CRCSPs. Although some programs target higher or lower extremes, the average age range in the programs was as recommended by the EU commission.[4,56] Most programs, especially in Europe, used population registers as the primary sources for identification of the target population while carrying out exclusions before or after campaign invitations. Despite the disparity in terms of number and types of exclusion criteria, the study highlights the existence of five consensual criteria, which are applied by more than 50% of programs. To carry out these exclusions, MADB, especially Claims-DB, was systematically used in certain programs, while others

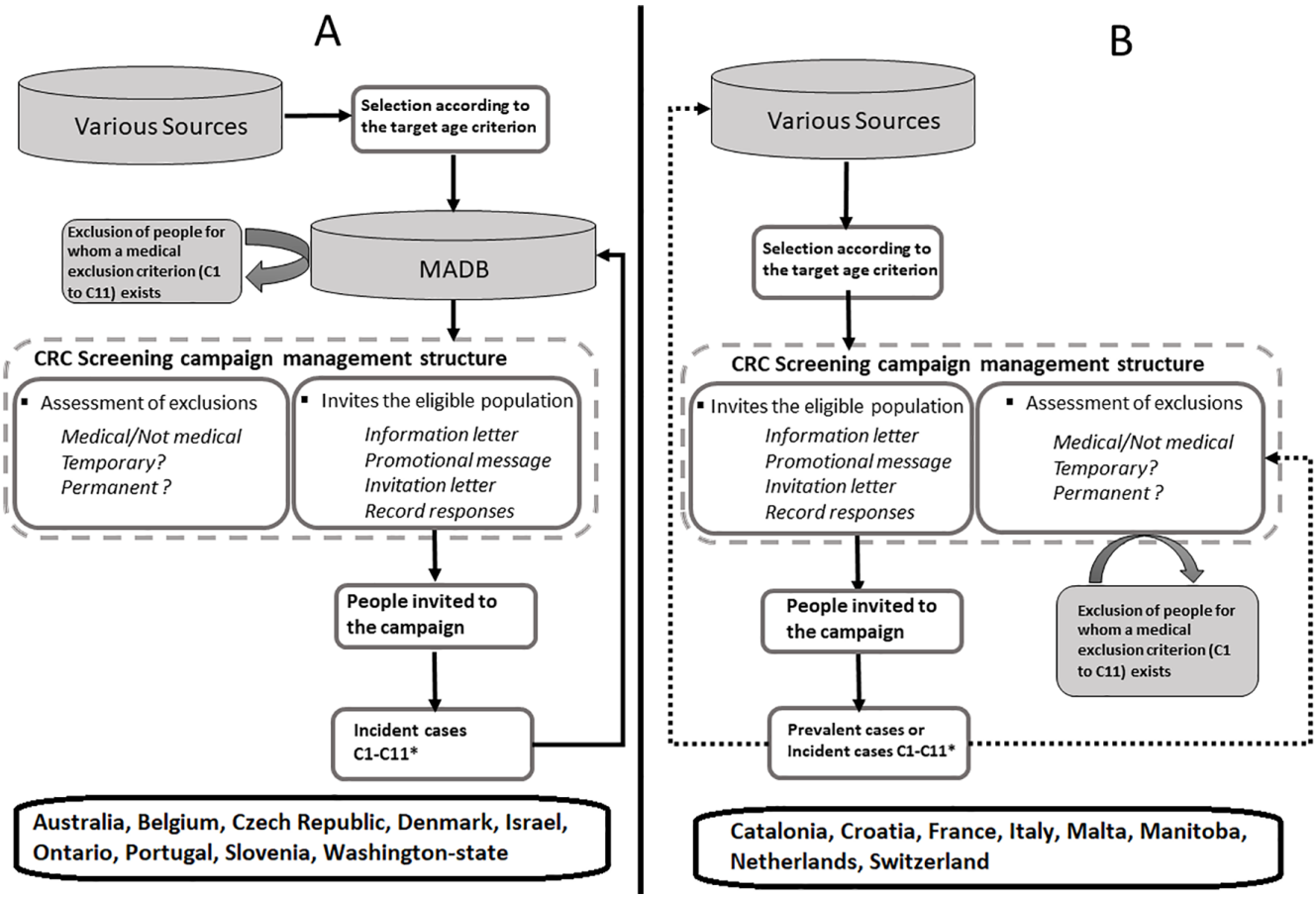


Figure 3. Executive summary of algorithms and schemes for selecting the eligible population in CRC screening programs in Type-A and Type-B programs.
C1, personal history of CRC; C2, family history of CRC; C3, personal history of IBD; C4, personal history of adenoma; C5, recent colonoscopy or sigmoidoscopy or CT colonography; C6, patient with transient benign pathology; C7, patient with another serious disease; C8, terminal phase of a severe disease; C9, high-risk genetic syndrome; C10, patient with symptoms of CRC; C11, other criteria.
CRC, colorectal cancer; IBD, inflammatory bowel disease.

only used information provided by patients or their attending physicians to refine their campaign target populations.

As recommended in Europe[57] and USA,[58] most CRCSP specifications recommend targeting people at average risk. But, to date because no program applies all the exclusion criteria that fall within the definition of high risk. The number of consensual criteria was certainly limited but consistent with the definition of CCR risk. The disparity (number and type of criteria) between programs revealed in this study argues the need for a redefinition of the CRCSP's eligible population.

Although the previous surveys were carried out at a time when several programs were in the pilot phase,[6,7] this study shows that the conclusions made are still valid. More meaningful comparisons of CRC screening participation indicators across programs are possible if participation indicators are calculated using consistent definitions and differences in program organization and population characteristics are considered.[6] For this standardization of definitions, our study suggests considering only the consensual exclusion criteria, which are the least subtle among the 11 criteria listed.

Transient benign pathologies, other serious diseases, particularly those in the terminal phase, are certainly morbid situations that can prevent the performance of a screening test, but they are not necessarily CRC risk factors; their inapplicability in many programs was therefore justified. About the family history of CRC, their subtlety is reinforced by the inaccessibility of the patient's

Table 4. Program evaluation indicators according to the chronology of medical exclusions, comparison of two strategies in four programs.

Programs refining the target population before the campaign invitation			**Programs (France, Catalonia, Slovenia) refining the target population after campaign invitation**					
Indicators reported	**Flanders (Belgium)**		**Indicators reported**	**France[a]**			**Slovenia**	**Catalonia (Spain)**
				National level	**Examples at departmental level**			
					Isère	**Haute-Savoie**		
Campaigns year	**2019**	**2020**	**Campaigns year**	**2019–2020**	**2019–2020**	**2019–2020**	**2019–2020**	**2020–2021**
Size (*N*) of target population	2,006,959 (100.0)	2,116,369 (100.0)	Size (*N*) of target population	20,308,341	369,470	236,941	674,637	500,000
The number (*T*) of people invited was unknown before refining (*N*), see below			Number (*T*) of people invited to the campaign (% in *N*)	NA	344,973 (93.4)	180,624 (76.2)	614,439 (99.6)	474,716 (94.9)
Number (*A*) of medical exclusions (% in *N*), of which:	817,094 (40.7)	976,543 (46.1)[†]	Number (*A*) of medical exclusions (% in *N*), of which:	NA	23,241 (6.3)[b]	4658 (2.0)[b]	23,979 (3.6)[†]	9912 (2.0)[†]
Diagnosed with CRC <10 years (C1): Total (% in A)	6438 (0.8)	6586 (0.7)	Personal history of CRC (C1): Total (% in A)	NA	187 (0.8)	72 (1.5)	387 (1.6)	3300 (33.3)
Full colonoscopy (only complete) <10 years (C5): Total (% in A)	484,919 (59.3)	520,397 (53.3)	Family history of CRC (C2): Total (% in A)	NA	1496 (6.4)	598 (12.8)	CNA	1558 (15.7)
Virtual colonoscopy <4 years (C5): Total (% in A)	1191 (0.1)	1154 (0.1)	Personal history of IBD (C3): Total (% in A)	NA	240 (1.0)	448 (9.6)	406 (1.7)	993 (10.0)
Opportunistic screening in past 2 years (C11): Total (% in A)	42,675 (5.2)	41,573 (4.3)	Personal history of adenoma (C4): Total (% in A)	NA	1871 (8.1)	739 (15.9)	5293 (22.1)	1379 (13.9)
Participation in screening program in year −1 (C11): Total (% in A)	280,648 (34.3)	405,517 (41.5)	Colonoscopy/CT colonography (C5): Total (% in A)	NA	19,226 (82.7)	2694 (57.8)	17,714 (73.9)	2641 (26.6)
Full colectomy (C11): Total (% in A)	1223 (0.1)	1316 (0.1)	Another serious disease (C7), or disease in terminal phase (C8)	NA	CNA	CNA	179 (0.7)	57 (0.6)
			High-risk genetic syndrome (C9)	NA	231 (1.0)	107 (2.3)	CNA	CNA
Eligible (*B*), after exclusions from target population: Total (% in *N*)	1,189,865 (59.3)	1,139,826 (53.9)	The invited persons were deemed eligible a priori (*B* = *T*), see above					

(Continued)

Table 4. (Continued)

Programs refining the target population before the campaign invitation			Programs (France, Catalonia, Slovenia) refining the target population after campaign invitation					
Indicators reported	**Flanders (Belgium)**		**Indicators reported**	**France[a]**			**Slovenia**	**Catalonia (Spain)**
				National level	**Examples at departmental level**			
					Isère	**Haute-Savoie**		
Campaigns year	**2019**	**2020**	**Campaigns year**	**2019–2020**	**2019–2020**	**2019–2020**	**2019–2020**	**2020–2021**
Invited in year *X*–1 (previous screening year)	341,638	412,929	Number of medical exclusions (% in *T*)[c]	NA	23,241 (6.7)[b]	4658 (2.6)[b]	23,979 (3.9)	9912 (2.1)
Eligible to invitation (*T*)	844,173	720,474						
Eligible to invitation and invited	828,596	705,887						
Invited although later an exclusion registered[d]	15,577	14,587	Number (*U*) of exclusions for any cause (% in *N*)[††]	2,828,436 (13.9)	45,820 (12.4)[b]	8173 (3.4)[b]	27,011 (4.4)	22,625 (4.5)
Finally, Number (*U* = *N*–*T*) of exclusions for any cause (% in *N*)	1,162,786 (57.9)	1,395,895 (66.0)[†]	Number (*U*) of exclusions for any cause (% in *T*)	2,828,436 (NA)	45,820 (13.3)	8173 (4.5)	27,009 (4.4)[†]	22,625 (4.8)[†]
Total coverage: Number (% in *N*)	1,296,544 (64.6)	1,344,730 (63.5)[†]	Total coverage: Number (% in *N*)	NA	148,780 (40.3)	63,012 (26.6)	373,901 (62.3)[†]	222,781 (44.5)[†]
Coverage by medical exclusion: Number (% in *N*)	493,771 (24.6)	529,453 (25.0)	Coverage by medical exclusion: Number (% in *N*)	NA	23,241 (6.3)	4658 (2.0)	23,884 (4.0)	17,061 (3.4)
Coverage by screening in current year or year –1: Number (% in *N*)	721,056 (35.9)	745 680 (35.2)[†]	Coverage by screening in current campaign: Number (% in *N*)	5,075,943 (25.0)	125,539 (34.0)	58,354 (24.6)	350,017 (58.3)[†]	205,720 (41.1)[†]
Coverage by opportunistic screening: Number (% in *N*)	68,140 (3.4)	59,692 (2.8)	Coverage by opportunistic screening: Number (% in *N*)	CNA	CNA	CNA	CNA	CNA
Coverage by colonoscopy carried out in current year: Nb (% in *N*)	13,577 (0.7)	9905 (0.5)	Coverage by colonoscopy carried out in current year: Nb (% in *N*)	NA	NA	NA	NA	NA

[a]Two French department chosen: Isère has three partnerships (Cancer Registry, Primary Health Insurance Fund, and Medical Information Service of the Grenoble University Hospital) to optimize exclusion and Haute-Savoie, having no partnership, only makes its exclusions after the return of patients or their treating physicians.
[b]$p < 0.05$ in comparison Isère versus Haute-Savoie by Pearson's Chi-square test.
[c]The exclusion rate is expressed by the ratio between the number of exclusions and the total number of invitations to the biannual campaign.
[d]Administrative delay in dataflow, so at the moment of the exclusion, the screening management structure did not know, and an invitation was sent.
[††]The total exclusion for any cause is expressed by the sum of non-medical exclusions (refusal to participate, invitation letter not received due to incorrect address, moving, death) and exclusions for medical reasons (C1–C11).
[†]$p < 0.05$ in comparison by Pearson's Chi-square test between programs (Flanders 2020, Slovenia 2019–2020, and Catalonia 2020–2021).
CNA, criteria not applicable in the program; CRC, colorectal cancer; IBD, inflammatory bowel disease; NA, not available.

selection process data, already mentioned.[8] The inaccessibility of data was highlighted in this study by the Ontario program in which application of the recommendations was obsolete due to a lack of information in the MADB as commented by the survey respondent: "[. . .]data regarding family history of CRC is not available through the administrative databases in Ontario therefore, exclusions to the correspondence campaign based on family history directly cannot be applied, however, people with a recent colonoscopy are excluded, indirectly excluding people who are being screened through the increased risk arm of the program."

This study supplies an understanding of the exclusion practices in force in the CRCSPs while highlighting consensual criteria that, if applied by all, would improve the comparability of participation rates between programs. The comparison of exclusion data (2019–2020) shows that the number of exclusion criteria has no impact on the exclusion rate. We can deduce from these exclusion data that connecting the screening database with other databases (or their regular use) would perfect the exclusion rate.

In addition to its impact on perfecting the exclusion rate, the use of MADB allows reproducible filtering, which could guarantee a consensual method of selecting the eligible population. However, the absence of a MADB in some countries or the unavailability of information in the MADB in others are major obstacles that are difficult to overcome in the short term. As for the inaccessibility of MADBs observed in certain countries (e.g., France), it could be resolved in the short term if the public decision to implement a screening program is supported by political willingness to allocate resources for the sustainability of the program. This suggests that standardizing the five consensus criteria across all programs would only be effective if the disparity caused by systemic failures in the organization of each program was controlled.

Cancer registries are recognized as essential for an adequate evaluation of cancer screening programs, but they are not involved in the evaluation of screening in several European countries.[59] For these authors, the lack of involvement of cancer registries was a major obstacle to improving the effectiveness of European programs. About 8 years after this finding, there are still countries (i.e., France) not fully covered by a cancer registry and several programs without interconnections with existing cancer registries.

Prior to the MADBs' use as a standard exclusion data source, standardization of the querying algorithms appears necessary, particularly in the European Union area, where there is a prospect of setting up a European health data space (EHDS). In its current form, the European Commission proposal does not stipulate specific standards that must be universally adopted to ensure semantic and syntactic interoperability.[60] The MADBs use various and non-interoperable terminologies; the definition of standards is a requirement for the migration of screening data in this EHDS.

Before using MADBs, new strategies will also need to be put in place to minimize the number of people wrongly included/not included in campaigns because none of the MADB query algorithms have 100% accuracy.[17,22,29,37] In addition, there was a diversity of computational definitions of morbid situations, which compromises any standardization of the definition of the person to be excluded from CRCSP campaigns.

Study limitations

Although the response rate was 75%, the lack of respondents in 25% of the countries surveyed is a major limitation of this study. Indeed, in most of these non-responding countries, a program exists, but the approach to selecting the target population is poorly documented. In a few, a MADB exists, but its connection with the screening program database is not discussed in the literature to our knowledge. The selection algorithm thus argued in this study cannot be generalized.

Conclusion

CRCSPs only partially target average-risk individuals due to incomplete exclusion data. Despite variability in exclusion criteria, five consensual criteria emerge as the least subtle and easiest to collect with available resources. These criteria can be queried in most MADBs, though not all programs use them. Standardizing these criteria could improve program comparability and facilitate a consensus-based selection method for screening populations.

However, the absence of a MADB in some countries or the unavailability of information in the MADB in others are major obstacles that are difficult to overcome in the short term. As for the inaccessibility of MADBs observed in certain countries, it could be resolved in the short term if the public decision to implement a screening program is supported by political willingness to allocate resources for the sustainability of the program. This suggests that standardizing the five consensus criteria across all programs would only be effective if the disparity caused by systemic failures in the organization of each program was controlled.

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Declarations

Ethics approval and consent to participate

All methods were carried out following relevant guidelines and regulations. According to the current French legislation, a study that does not change the care of patients does not require the opinion of the Clinical Research Ethics Committee. This article does not have any studies with human participants performed by any of the authors. This study does not involve human participants, informed consent was therefore not needed. This article does not have any studies with animals performed by any of the authors.

Consent for publication
Not applicable.

Author contributions
Akoï Koïvogui: Conceptualization; Data curation; Investigation; Methodology; Project administration; Validation; Visualization; Writing – original draft; Writing – review & editing.

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Availability of data and materials
Survey material/data are available upon request. Screening data provided by the coordinators should be requested from the program coordinators in the respective countries/regions.

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Appendix

Abbreviations

3BT	Thesaurus Bilingual Biclassified Belgian
ACD	Australian Cancer Database
ACHI	Australian classification of health interventions
APR-DRG-X	all patient refined diagnosis related group version Xth
CCAM	Classification Commune des actes Médicaux
CCI	Canadian classification of interventions
CHS	CLALIT health services
Claims-DB	Regional or National Health Insurance Database
CNA	criteria not applicable in the program
Colo	colonoscopy/sigmoidoscopy/ CT colonography
CPT	current procedural terminology
CRC	colorectal cancer
CRCSP	population-based colorectal screening program
DNPR	Danish National Patient Registry
EHDS	European Health Data Space
HER	electronic health record
FIT	fecal immunochemical test
FS	flexible sigmoidoscopy
gFOBT	Guaiac fecal occult blood test
HCPCS	healthcare common procedure coding system
HMDB	hospital morbidity database
HMO	Health Maintenance Organizations
IBD	inflammatory bowel disease
ICD-0-X	International Classification of Diseases for Oncology Xth edition
ICD-X	International Classification of Diseases, Xth revision
AM	Australian Modification
CA	Canadian adaptation
CM	clinical modification
DV	Danish version
GM	German modification
PCS	procedure coding system
ICPM	International Classification of Procedures in Medicine
IMA	The Intermutualistic Agency
INCR	The Israel National Cancer Registry
KPCHR	Kaiser Permanente Center for Health Research
LOINC	logical observation identifiers, names, and code
MADB	Medico-Administrative Database
MADB	other medical administrative database
MBS	medical benefits schedule
MS-CRCSP	program management structure
NA	not available
NHIS	National Hospital Information System
NHMD	National Hospital Morbidity Database
NOMESCO	Nordic Medico-Statistical Committee
NRHOSP	National Register of Hospitalized Patients
OHIP	Ontario Health Insurance Plan
P	permanent
RON	Registo Oncológico Nacional
SKS	Sundheds-vaesenets klassifikations system
SNDS	Système National des Données de Santé
SNOMED CT	systematized Nomenclature of Medicine Clinical Terms
T	temporary
WSCR	Washington State Cancer Registry